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# ABSTRACTS FROM ASTRONOMICAL PUBLICATIONS.

*On the Reliability of Parallax Determinations.*—Because of the minuteness of the quantities to be determined, there are few more difficult problems in astronomy than the subject of the distances of the stars. It is interesting to trace the general development of the various methods and to note the slow but constant improvement in this field during the past quarter century. We have seen the probable error of a single determination of stellar distance gradually sink from the thirty of forty thousandths of a second of arc in the better values secured by the meridian circle or the heliometer to nine or ten thousandths in the most recent photographic measures with instruments of great focal length. Even this great gain in accuracy leaves us still far from the desired goal, as may be realized when we consider that the probable error of even the most refined photographic methods is still somewhat larger than the average parallax of all naked-eye stars, and that we are able to determine the distances of only the inner fringe of stars in the stellar universe about us, and those with a considerable measure of uncertainty.

Just how far can we rely upon existing measures of stellar distance? May we trust such determinations with the determined probable error as an approximte guide to their accuracy, or have we reason to suspect the existence of systematic errors?

This point is taken up by Professor A. S. Flint in the *Astronomical Journal,* No. 696, September 26, 1916, in a paper entitled "On Evidences of Systematic Variation in Recent Longer Series of Determinations of Stellar Parallax." The method, in brief, was to compare each series of determinations with the average of all the better modern authorities, and the paper is illustrated with numerous diagrams showing the results of comparisons of each authority with the mean of all, and generally also with the long and homogeneous series of stellar parallaxes determined at Yale with the heliometer.

Evidences are found of such systematic errors in most of the series, which include several with the meridian circle, two with the heliometer, and three by photography.

Of Professor Flint's conclusions, the following may be noted:

1. Parallaxes observed with the heliometer are liable to variable systematic error, arising to somewhat more than the probable error of their better-determined values. When corrected for such systematic error, heliometer parallaxes are superior as regards both constant and variable systematic error.

2. Meridian circle determinations, especially with the travelling thread micrometer, are but little inferior to heliometer determinations.

3. Perhaps Flint's most revolutionary conclusion, and one which is not likely to be accepted at once by those working in the photographic field, is to the effect that recent photographic determinations, altho the most refined of all as regards individual parallax stars, are subject to fairly large variable systematic errors.

The Yale series is corrected for a systematic error varying with the right ascension, and ranging from $+0''.029$ to $-0''.015$; similarly, both of Flint's series are corrected for a magnitude error. One must confess to a feeling that any such corrections, approaching in magnitude the probable error of single parallax determinations, must be supported by a great mass of evidence to be regarded as valid. Why, too, should we assume that the mean of all authorities, the majority of which are subject to probable errors three times that of modern refined photographic determinations, is necessarily more trustworthy and worth accepting as a standard than such refined photographic parallaxes themselves? What is needed is, as photographic parallaxes multiply, a comparison of various photographic series among themselves, or a comparison of all modern values regarding the photographic values as a standard.

H. D. Curtis.

*Space, Time, and Gravitation.**—The interesting theory of relativity continues to fill a good deal of space in contemporary physical research. A brief outline of the theory was given in this PUBLICATION, Vol. **23**, 219, but the theory as originally put forward by Einstein has been subjected to so many alterations as now to be referred to as the "old" theory of relativity. In its present form all laws of nature must be invariant for *any* transformation of coördinates, instead of for one particular class of transformations as in the earlier Einstein theory. "Gravitation is thus put on quite a different footing from all other forces of nature—it is no longer a 'force,' properly speaking—it is more of the nature of a property of the four-dimensional time-space, imparted to it by matter or energy located in it." In place of our ordinary three-dimensional Euclidean space, we have now postulated a four-dimensional time-space, where time is the fourth parameter. The mathematics of such a physical universe is somewhat complicated, but it seems to fit well with all observed phenomena. Of the more important astronomical bearings of the theory three points may be mentioned. There should theoretically be a minute deflection of a ray of light passing thru a strong gravitational field, and stars in the neighborhood of the eclipsed Sun should show a slight apparent increase of distance from the Sun's center. This is perhaps the only direct physical observation which can be made to test the theory; plans had been made to test this point during the total eclipse in Russia in 1914, but no results were secured because of clouds. The spectrum lines from the Sun or massive stars should also show a displacement toward the red; in the case of the Sun it would amount to about 0.6 A, and it has been suggested, tho doubtless without foundation, that the so-called K-term in the solutions for the solar motion might be due to this cause. There are such shifts in solar lines, but not the same for all lines, and probably due to other causes. Finally, the theory removes the outstanding discrepancy in the motion of *Mercury*.

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* On Einstein's Theory of Gravitation, and its Astronomical Consequences. W. de Sitter, *Monthly Notices*, 699, 1916.

Space, Time, and Gravitation, by W. de Sitter. *The Observatory*, October, 1916.
Einstein's Theory of Gravitation. T. J. J. See, *ibid*, December, 1916.

Many will feel that the idea of a four-dimensional time-space is fully as difficult of comprehension as was the mystery of gravitation, all-pervading, inexplicable, in our classical physical theories. While the mathematician is willing to admit that many other forms of space or geometries of space would satisfy physical science as well as the Euclidean, we must confess that we are still of the point of view of the mathematician who stated that, while it would be possible, in a four-dimensioned universe, to turn an egg inside out without breaking its shell, still he realized that there were many practical difficulties in the way of the accomplishment of this feat.

To this extent one may sympathize somewhat with Professor See's point of view. However, the impressive quantities which he quotes as examples of the mighty force of gravitation, tho often used in this connection, are apt to be misleading. An equation of the form $\infty . 0 = x$ may have almost any value for its second member; only when we deal with the almost infinite masses of astronomy will $x$ be very great, for the fact remains that gravitation is so minute, so infinitesimal in comparison with the ordinary forces with which the physicist deals, that it may well be regarded as zero in comparison with them. Given two masses of matter, one composed entirely of positive, and the other of negative electrons, we can calculate the electrostatic attraction between these masses, itself not an unduly powerful force, but one with which the physicist has frequently to deal. Calculating now in like manner the gravitational attraction between the same two masses, how much smaller is the gravitational than the electrostatic attraction? It is smaller in the ratio of unity to $10^{41}$! In words, gravitation is one hundred thousand billion billion billion billion times the smaller.

In its unification of all matter and all forces in a single simple and homogeneous system the theory of relativity is certainly an attractive one, to say the least. Tho it, too, may eventually pass into the limbo of discarded physical theories, its future development and possible applications will be followed with great interest. H. D. CURTIS.

*Distances and Distribution of Class B Stars.*—In a recent contribution to Studies in Stellar Statistics[1], Charlier has derived a system of distances for Class B stars as a group. These values of distance depend upon apparent magnitudes and a factor or parameter determined from proper motions and radial velocities. The following points led up to this investigation: Differences in the intrinsic brightness of the stars in a spectral class are probably least among the early class stars. It may then be assumed as a working hypothesis that Class B stars have similar absolute luminosities. Again, the apparent brightness of the individuals of a class of stars is affected more by their distances than by their small differences of intrinsic brightness. Therefore the more or less approximate distance is directly determinable by the apparent magnitude. Luminosity, however, depends upon radius and intrinsic brightness. But whatever the circumstances Charlier's previous investigations have led him to the conclusion that Class B stars have similar luminosities.

The relation between distance and magnitude is based upon Pogson's law, that the ratio of luminosities of two stars whose difference of magnitude is $\delta m$ is proportional to the $\delta$mth power of the 5th root of 100. The luminosities are also inversely proportional to the squares of the distances. Therefore in self-explanatory symbols

$$\frac{L_1}{L_2} = \frac{r^2_2}{r^2_1} = 100^{\frac{1}{5}\delta m}$$

If $R$ is distance for zero magnitude, then

$$\mathrm{r} = R\,10^{\frac{1}{5}\mathrm{m}}$$

$R$ is the factor or parameter to be determined. Obviously it must vary from star to star because of differing spectral class, radius, and intrinsic luminosity. But its range among Class B stars will be small for the same reasons as for that of their absolute luminosities. Because of this variation only a mean value of $R$ may be obtained. To derive it we have the following equations in which $\mu$ is proper motion and $U$, $V$, $W$, are linear components of velocity in the equatorial system:

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[1] *Publ. Lund Obs. Meddelande,* No. 14, 1916.

$$\begin{aligned} r\mu_\alpha \cos\delta &= R\,10^{1/5 m}\,\mu_\alpha\cos\delta = -\sin\alpha U + \cos\alpha V \\ r\mu_\delta &= R\,10^{1/5 m}\,\mu_\delta = -\sin\delta\cos\alpha U - \sin\delta\sin\alpha V + \cos\delta W \\ \text{rad. vol.} &= \cos\delta\cos\alpha U + \cos\delta\sin\alpha V + \sin\delta W \end{aligned}$$

Charlier has adopted for his unit of distance the Siriometer with the following equivalents:

1 Sir. = 16 light-years = 1,000,000 astronomical units

The radial velocities are consequently expressed in Siriometers per stellar year, and the values of $U$, $V$, $W$, follow in the same units.

The first step is a least squares solution for $U$, $V$. $W$, from the third equation using all values of radial velocity available, while the second step is solution for $\frac{U}{R}$, $\frac{V}{R}$, $\frac{W}{R}$, from the first and second equations, adding the normal equations resulting from them. A value of $R$ then follows from

$$R = \frac{\sqrt{U^2 + V^2 + W^2}}{\sqrt{\left\{\frac{U}{R}\right\}^2 + \left\{\frac{V}{R}\right\}^2 + \left\{\frac{W}{R}\right\}}}$$

156 stars were available for determining $U$, $V$, $W$, and 479 for $\frac{U}{R}$, $\frac{V}{R}$, $\frac{W}{R}$. The procedure was performed for each spectral sub-class with these results:

| | |
|---|---|
| $B_0$ | R = 2.67 |
| $B_1$ | 7.36 |
| $B_2$ | 7.36 |
| $B_3$ | 3.42 |
| $B_5$ | 3.73 |

It is thus evident that $R$ varies with spectral class and that Classes $B_1$ and $B_2$ are four times as luminous as $B_0$, $B_3$, $B_5$. Further, that if the corresponding values of absolute luminosity have any relative physical significance, then Class $B_0$ follows $B_5$. Charlier does not further discuss these points, but awaits the results of further investigation. His main object at this time was to derive the values of distance $r$ and the corresponding parallaxes which he gives in a catalog of 805 Class B stars brighter than the 6th magnitude.

A few of the incidental deductions are of interest. Class B stars, as far as observed, seem to form a cluster of spheroidal form, which is well shown by his charts of distances projected onto the XY plane and of projected distances and galactic latitudes in the XZ and YZ planes. The stars are found within a radius in the Galactic Plane of about 200 Sir. or 3200 light-years from the Sun and within 60 Sir. or 960 light-years in the direction of the Galactic Pole. The center of the group lies in the direction of the constellation *Carina* and the Sun is 18 Sir. from the center and 4 Sir. north of the Galactic Plane. This investigation yields for the motion of the Sun $21\frac{1}{4}^{\mathrm{km}}$ to right ascension 273° and declination +34°. The stars appear to have a normal distribution following a simple law, fairly uniformly distributed in the central region and thinning out beyond 100 Sir. The density in the central region is equivalent to one star in a cube whose edge is 116 light-years. The theory of velocity surfaces applied to this group of stars is found to give an ellipsoid of revolution about the Galactic Polar Axis with a diameter for this direction about ⅔ that in the Plane. This would indicate a preponderance of motion parallel to the Galactic Plane and is in accord with the evidence of such motion which led Plummer[2] to adopt it as a hypothesis for his investigation of stellar motions. Charlier considers his results for the structure of the group of B stars indicative of that of the general star-system since not less than the 8th magnitude pertains to some of the farthest stars because of the great luminosity of B stars. A partial comparison of Charlier's parallaxes with those of Kapteyn[3] derived upon the hypothesis of stream motion and with those of Plummer[2] based upon the hypothesis of motion parallel to the Galactic Plane does not show any close agreement. There appears to be a systematic difference between Charlier's and Kapteyn's values, the latter indicating less distance for Class B stars.

G. F. Paddock.

December, 1916.

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[2] *Mon. Not.* **73**, 174, 1913.

[3] *Ap. Jour.* **40**, 43, 1914.